at New Haven in the following-named years, including 1816:

1806, June 4, frost, temperature 40°.
1816, June 11, frost, temperature 35°.
1843, June 2, frost, temperature 36°.
1859, June 12, frost, temperature 37°.
1864, June 11, slight frost, temperature 41°.

The cold April and May of 1857.—Passing down the line of years from 1816 it will be found that the next pair of consecutively cold months occurred in 1857. As a cold month, April of that year has not been surpast in many places during the last ninety odd years. This is especially true of the upper Mississippi Valley, where the April mean temperature in 1857 at Fort Snelling, Minn., was but four-tenths of a degree above the freezing point, or nearly 5° below the April mean of 1907. The month of May, 1857, was not so cold as May, 1907. In the eastern part of the country the month last named was 4° to 8° colder than May, 1857. Considering the entire period, April 1–May 31, there is little difference between the two years.

So far as can now be ascertained, the effect of the cold weather of April and May, 1857, on the crops was not especially injurious. Some cornfields were replanted, since a lack of heat and excessive rains in the latter part of May caused the seed to rot in the ground. June and the summer months following were warm, and, unlike the present year, the warm weather began June 1, instead of the 15th. A good crop was produced, altho the yield of fruit was somewhat less than the ordinary.

The great frosts of June 5 and 11, 1859.—Two years after the cold spring of 1857, in what had thus far been a normal season, a change of temperature in a single night spread destruction over a large proportion of the wheat fields from eastern Iowa to New York. The corn crop and a great part of the garden truck in the same districts were killed. A killing frost, coming at a time when the wheat was generally considered as past all danger from freezing, overwhelmed the country with astonishment. The areas affected by this destructive freeze were eastern Iowa and Minnesota, northern and central Indiana and Illinois, Wisconsin, Ohio, Michigan, all of Pennsylvania and New York, except the southeast portions, and northern New England. In some localities thin ice was formed in vessels and stagnant pools. The frost of June 11 was not so severe as that of the 5th and 6th. The weather in the west turned cold on the 3d, and the low temperatures continued thruout the 4th with a heavy frost west of the Alleghenies on the morning of the 5th, and to the eastward on the morning of the 6th. Much of the wheat, being in full head and the grain in the milk, was ruined. The peach and apple crop was only partially destroyed. The corn that was but a few inches above ground recovered from the injury and produced a fair crop. The corn that had attained a height of 12 to 18 inches was replanted. Fortunately, the autumnal frosts did not occur until about the close of October, and the replanted fields were fully matured.

In 1874 and 1875 April and May were both deficient in temperature, April especially, but not so markedly as in 1857 or 1907. Wheat in 1874 was a good crop, the yield per acre in the spring wheat States being, however, lower than usual. The corn crop was 82,000,000 bushels less than the crop of 1873. Only a portion of this reduction can be charged to the cold weather and frost, since it was also injured by local droughts and the depredations of the chinch bugs, especially in the west. Conditions were unfavorable for a large crop of oats, but it is impossible to state the effect of the backward weather in the spring.

The average yield of corn per acre in 1874 was low, viz, 20.7 bushels, and the price was high, 64.7 cents per bushel. In 1875 the rate of yield was increased to 29.4 bushels per acre, but the price dropt to 42 cents. The average yield of wheat was reduced 1.3 bushels per acre, and while the aggregate quantity was 16,000,000 bushels less than in 1874, the aggregate value was about $3,500,000 more.

The oat crop was large and the price correspondingly low. The barley, potato, and cotton crops were excellent and prices low.

From the foregoing it would seem that the chance of injury to the staple crops of this country by reason of a backward spring is rather remote, provided, of course, a sufficient amount of heat is supplied in June. In the notable summer of 1816 corn and hay were the only two crops that suffered serious injury, and that summer was the coolest of a century. Drought and heat are much more likely to make serious inroads on the crops than are the chilling blasts of April and May.

BARNES'S "ICE FORMATION WITH SPECIAL REFERENCE TO ANCHOR ICE AND FRAZIL."

By W. W. COBLENTZ. Dated Washington, D. C., June 17, 1907.

The present book by Prof. Howard T. Barnes, of McGill University, is the result of the need which has arisen for republishing the author's various papers on the formation of river ice. It is the story of the ice formation in the St. Lawrence River, and is of especial interest in connection with hydraulic development in the far North, where the winters are long and intensely cold.

The phenomena connected with the formation of river ice are very complex, and, in presenting the subject, the author has very wisely included the elementary notions concerning heat transfer.

The book is divided into eight chapters, which treat of—1, the physical laws governing the transfer of heat; 2, the physical constants of ice; 3, the formation and structure of ice; 4, sheet, frazil, and anchor ice; 5, precise temperature measurements; 6, river temperatures; 7, theories to account for frazil and anchor ice; 8, methods of solving the ice problem in hydraulic engineering work—e. g., steam and electric heating of penstocks, racks, etc., in hydraulic power plants.

In Canada, as well as other localities in high latitudes, three kinds of ice are observed, viz, sheet or surface ice, frazil, and anchor ice. *Surface ice* is found only in still water, and is caused by the loss of heat to the cooler atmosphere, by radiation and conduction from its surface. Thickening of the ice sheet takes place downwards by conduction and radiation of heat thru the ice to the air.

Frazil is the French-Canadian term for fine spicular ice, from the French for forge cinders which it is supposed to resemble. It is formed in all rivers or streams flowing too swiftly for the formation of surface ice. A dull, stormy day, with the wind blowing against the current, is productive of the greatest amount of frazil, which, like anchor ice, has a tendency to sink upon the slightest provocation, and to follow submerged channels until it reaches a quiet bay. Here it rises to the under side of the surface ice, to which it freezes, forming a spongy growth, attaining great thickness; in some cases the author observed a depth of 80 feet of frazil.

Anchor ice, as the name implies, is found attached or anchored to the bottom of a river or stream, and often attains a thickness of 5 to 6 feet. It is also called ground ice, bottom ice, and ground-gru. In a shallow, smooth-flowing river we are more likely to have anchor ice formed in excess, whereas in a deep and turbulent stream we are likely to have more frazil. In a river 30 to 40 feet deep anchor ice is almost unknown, altho large quantities of frazil are met with.

We quote the following from Professor Barnes:

The various facts of common observation in connection with anchor ice point to radiation as the primal cause. Thus, it is found that a bridge or cover prevents the formation of anchor ice underneath. Such a cover would act as a check to radiation, and reflect the heat waves back again to the bottom. Anchor ice rarely forms under a layer of surface ice covered with snow. It forms on dark rocks more readily than on light ones, which is in accord with what is known as to the more copious radiation of heat from dark surfaces. Anchor ice never forms under a cloudy sky either by day or by night, no matter how severe the weather, but it forms very rapidly under a clear sky at night. Anchor ice is readily melted under a bright sun. It seems highly probable, then, that radiation of heat supplies the necessary cooling to the bottom of a river to form the first layers of ice, after which the growth or building up of the ice is aided by the entangling and freezing of frazil crystals which are always present in the water.

The author found that during rapid ice formation the water becomes slightly undercooled, to the order of a few thousandths of a degree, and that the ice which is formed is in a very adhesive state. On the cessation of cold weather the temperature of the water rises slightly above the freezing point and the ice gradually melts. Anchor ice rises from the bottom in mild weather, and also in extreme cold weather under the influence of a bright sun, when it is dangerous to small boats. It is also known to lift and transport large boulders. On the other hand, a bright sun prevents the water from becoming undercooled and the formation of frazil. The author's conclusion that anchor ice is formed by radiation rather than by conduction is practically the same as that of Farquharson in 1841. It explains the observed phenomena better than any of the other theories propounded. Thus the loosening of the anchor ice under a bright sun is simple enough from the fact that water is transparent to heat waves up to 1 μ ($\mu = 0.001$ mm.). The thickness of the layer of ice that must be melted in order to overcome the adhesion to the rock surface must be of molecular dimensions. In addition to this, there is the tension on the rock surface due to the buoyancy of the ice, which also tends to melt the ice. The explanation of the formation of anchor ice is more difficult, and the author's statement that "It is not to be supposed, because a substance like water has been found to be highly opaque to the radiation from hot bodies, that it will be the same for cold body radiation", is a little startling, and not very clear. There is no evidence for saying that "It is probable that water possesses an absorption band for shorter heat waves, but may become perfectly transparent for the longer heat waves".

It is known that water is exceedingly opaque to heat waves from 4 to 8 μ, but more transparent in the region from 8 to 20 μ. (This was found by Rubens and Aschkinass for water vapor, which behaves like the liquid in its properties for absorbing heat waves, fig. 1.[1]). Beyond 20 μ there is great opacity, the heat waves at 50 μ were entirely absorbed, while at 80 μ theory predicts a band of metallic reflection. As a whole, water differs from most other substances in that its great opacity is due to numerous *small* absorption bands. Consequently its absorption coefficient is smaller than that of a substance like quartz which has bands of metallic reflection at 8.5, 9.02, and 20.75 μ. Hence, there is no objection to saying that "the whole question of the formation of anchor ice depends upon admitting that the long heat waves can penetrate freely thru water". For the maximum radiation of a body at a temperature of 0°C. lies in the region of the spectrum extending from wave lengths 8 to 20 μ, and it is here that water has its greatest transparency for long heat waves.

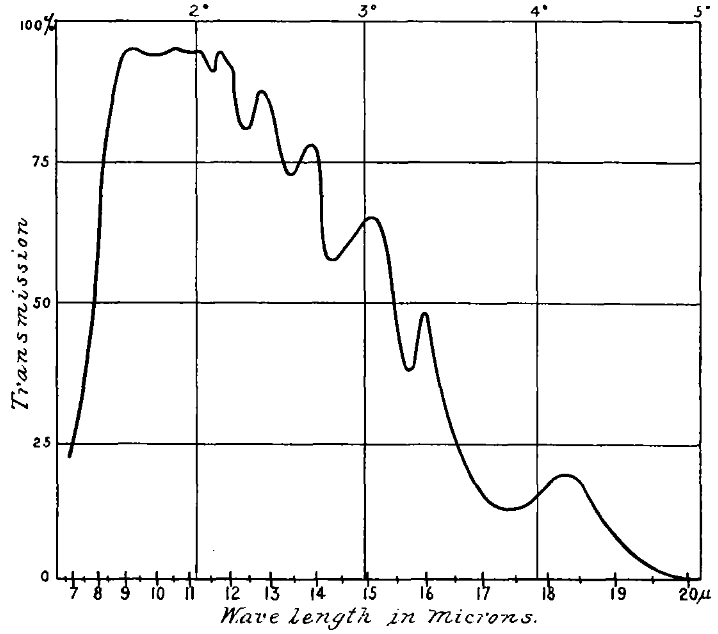

FIG. 1.—Transmission spectrum of water vapor (greatest transparency from 10-15 μ).

It is difficult to conceive of a more complex form of radiation than the one here involved. According to Prevost's theory of exchanges, when two bodies are at different temperatures the hotter receives energy from and imparts energy to the colder by radiation, and vice versa. In the case of the river, when the sky is clear, the water is radiating into space whose temperature is probably near the absolute zero. The river bed is radiating energy into the water, and probably thru it into space. Leaving out of consideration the special nature of the two bodies (water and river bed), it has been established (see Drude's Optics, p. 462) that the radiation from a "nonblack body" is approximately proportional to the square of the refractive index of the surrounding medium, which is transparent, so that from this standpoint the emissivity of the river bed into the water would be greater than that of the water into the air. Of course, if the water were transparent, its emissivity would be *nil*, and the problem would be less complex. Little is known concerning the special nature of these two bodies, but from the fact that the anchor ice separates so easily from the river bed, under a bright sun, it is evident that the absorption coefficient of rock material is greater than that of water, and, hence, that its emissivity must also be greater. Hence, more energy will be radiated from the river bottom than from the water, into space, the river bottom will become the cooler, and finally a film of ice will form on it. During cloudy weather the temperature of the water vapor in the air is equal to or higher than that of the water and the river bottom. There is then an equality in the radiation, or an excess is being emitted from the clouds to the earth. A certain amount will also be returned from the clouds by reflection. Hence, as a whole, the excess of radiation is toward the earth, and since the temperature of the clouds is above the freezing point no anchor ice is formed.

To sum up, from this elaboration of the author's explanation, just quoted, of the formation of anchor ice, it will be seen that it is not only possible but also highly probable that the cause is to be attributed to the greater emissivity of the substances forming the bed of the river, and to the greater transparency of water to heat waves than is generally supposed to obtain for that substance. As a whole, it is difficult to conceive that such a condition can exist, but the magnitude

[1] In the experiments by Rubens and Aschkinass the radiation from glowing zircon passes thru a heated iron tube thru which flows a steady stream of aqueous vapor at atmospheric pressure. The radiant beam falls upon a reflecting spectrometer provided with a sylvite prism, which is transparent to heat waves up to 25 μ. The energy transmitted in any part of the spectrum (after passing thru the column of water vapor) relative to the total energy of the original beam is measured by a thermopile, and is exprest by the ordinates 0-100 per cent, as in fig. 1. The complement of these ordinates is the relative energy absorbed by a layer of vapor 75 centimeters thick, saturated at 100° C. The horizontal scale at the bottom gives the wave lengths in microns as computed from the observed spectrometer settings, which are given at the top of the figure, namely, the angle of deflection for any wave length λ minus the constant angle of deflection for the sodium line, D.—EDITOR.

of the heat transfer required to bring about this ice formation must be exceedingly small, and the explanation given accounts for all of the facts observed.

HALOS AND RAIN OR SNOW.

By MARTIN L. DOBLER. Dated Lake Montebello, Baltimore, Md., December 27, 1906.

In compliance with the request in the MONTHLY WEATHER REVIEW of September, 1906, that voluntary observers should look up their old reports and tabulate the dates of halos and the condition of the weather for the twenty-four hours following, I am pleased to give you the best results that I can for the period of my record up to December 27, 1906. I will give both the halos that were followed by rain in twenty-four or thirty-six hours, and also those that were followed by clear weather.

TABLE 1.—*Halos and rain at Lake Montebello, Md.*

Date.	Halos.	State of weather following halo.
November 5, 1905	Solar	Rain, 0.06 inch, occurred on next day.
November 6, 1905	Lunar	Rainfall, 0.06 inch, occurred; partly cloudy.
February 4, 1906	Lunar	Trace of snow day following; cloudy.
February 12, 1906	Solar	Rain, 0.02 inch, followed on 3d day.
March 2, 1906	Lunar	Heavy rain, 0.53 inch, day following.
March 8, 1906	Lunar	Rain, 0.07 inch, occurred on this date.
March 24, 1906	Solar	Rain and snow, 0.03 inch, day following.
April 8, 1906	Solar	Tremendous rain, 1.96 inches, day after.
April 20, 1906	Solar	Trace of rain day after, and 0.13 inch on 3d day.
April 26, 1906	Solar	A partly cloudy day, with high temperature.
May 2, 1906	Lunar	A partly cloudy day; lightning at night.
June 10, 1906	Solar	Heavy rain, 0.71 inch, day following.
August 4, 1906	Solar	Rain, 0.01 inch, occurred 3d day after halo.
September 27, 1906	Lunar	Rain on same date; trace day following.
September 29, 1906	Solar	Rainfall, 0.03 inch, day following.
November 3, 1906	Lunar	Followed by no rain whatever.
November 23, 1906	Lunar	Followed by no rain.

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. FITZHUGH TALMAN, Assistant Librarian.

The committee appointed by the Governor of Hongkong to inquire whether earlier warning of the typhoon of September 18, 1906, could have been given to shipping has made a report entirely favorable to the officials of Hongkong Observatory. The storm is said to have been of very limited area—about one-eighth the diameter of the average typhoon—and to have moved so rapidly from a point of origin probably near Hongkong that early warning was impracticable. Doctor Doberck, director of the observatory, testified that it was "more like a tornado than a typhoon" and that it "bridges the gap heretofore existing between typhoons and tornadoes." The earlier warnings issued by Zikawei Observatory are said to have referred to a different depression, which passed northwest over Formosa. However, in a pamphlet recently issued from the Manila Observatory,[1] Father Algué maintains that the Formosa and Hongkong storms were identical, and publishes a chart showing the successive positions of the depression for a period of ten days.

It is reported in Symons's Meteorological Magazine for May that Doctor Doberck is about to retire from the directorship of Hongkong Observatory, which he has occupied since 1883.

At a meeting of the Royal Meteorological Society on April 17 a paper was read by Mr. R. L. Holmes on "The phenomenal rainfall in Suva, Fiji, August 8, 1906". About 41 inches of rain is said to have fallen in thirteen hours. This amount is partly estimated, owing to the fact that the gage overflowed several times. (The most remarkable case of excessive rainfall of several hours' duration mentioned in the 2d edition of Hann's Lehrbuch is a fall of 41.44 inches, in one day, at Cherrapunji, India.)

Mr. C. F. von Herrmann, until recently in charge of the Weather Bureau station at Baltimore and of the Maryland and Delaware Section of the Climatological Service, has contributed two memoirs on the local climatology of Maryland, viz, "The climate of Calvert County" and "The climate of St. Mary's County", to special publications of the Maryland Geological Survey devoted to the physical features of the counties in question. These climatological papers have also been issued separately (Baltimore: Johns Hopkins press. March, 1907). They continue the series begun by Dr. O. L. Fassig with "The climate of Allegany County" (Baltimore, 1900), to which the same writer added "The climate of Cecil County" (Baltimore, 1902) and "The climate of Garrett County" (Baltimore, 1902). In 1904 the Maryland Weather Service began publishing Doctor Fassig's "Report on the climate and weather of Baltimore and vicinity", two installments of which have been issued to date. This work, when completed, will probably be the most exhaustive treatise ever published in this country upon the climate of a single station and its neighborhood. The climate of the State, as a whole, was discussed by F. J. Walz in "Outline of present knowledge of the meteorology and climatology of Maryland", published in Maryland Weather Service, [special publication] Vol. I, p. 417-551, (Baltimore, 1899). This work includes abundant statistics concerning normal and extreme values of the meteorological elements, together with isothermal and isohyetal charts; but for collected data, i. e., data for the individual years of record, one must consult the series of county reports now in course of publication, and the special report on the climate and weather of Baltimore.

The Weather Bureau Library has recently received annual résumés of meteorological observations made at the Observatorio Cagigal, Caracas, Venezuela, under the direction of Dr. Luis Ugueto, during the years 1903–1906; also a summary of the rainfall at the same observatory during the years 1891–1902. These are the first meteorological data that have come to us from Venezuela for many years. The principal climatic statistics heretofore available for Caracas are summarized in Zeitschrift der Österreichischen Gesellschaft für Meteorologie, Bd. 7 (1872), p. 379–380. Comparing the results obtained at the Observatorio Cagigal with the earlier observations, we find certain systematic disagreements, especially in the mean temperature data, which are generally 2° to 3° C. lower in the former. It remains to be seen whether the older or the newer observations are at fault, or whether their discordance is to be accounted for by a decided difference in altitude. According to Doctor Ugueto's observations, the mean annual rainfall for the twelve years 1891–1902 was 807.9 mm. (31.81 inches).

Mr. W. F. Tyler, of the Chinese Imperial Maritime Customs, is still pursuing his investigation of the relation of meteorological conditions, especially temperature and humidity, to the sensation of discomfort. His first publication on this subject, "A scheme for the comparison of climates", was reviewed in the MONTHLY WEATHER REVIEW of May, 1904, p. 217. Now we have received a more extensive paper on the subject,[2] in which the psychological aspects of the question are more fully dealt with. The author's "hyther" scale ranges from 0 to 10, 0 representing a perfectly comfortable summer day at Shanghai—warm, but bright, brisk, and bracing—while 10 represents the very worst day ever experienced by the inhabitants of that city—hot, damp, and enervating. So far, discomfort due to cold has not been investigated.

A letter from Professor Scherer, director of the meteoro-

[1] Algué, José. The Hongkong typhoon, September 18, 1906. Advance sheets of the monthly bulletin of the weather bureau for September, 1906. Manila: Bureau of printing. 1906.

[2] Tyler, W. F. The psycho-physical aspects of climate, with a theory concerning intensities of sensation. London: John Bale, Sons & Danielsson. (Reprinted from the Journal of Tropical Medicine and Hygiene, April 15, 1907.)